**(BSP September 27, 2004)**

## Spherical Bearing

### Bearing Types

The spherical bearings shall be one of the following types, with bridge specific modifications, if any, as shown in the Plans:

#### Fixed Spherical Bearings With External Restrainer

Each bearing shall consist of an upper, a middle, and a lower unit. The lower unit shall be a masonry plate, a bottom keeper plate, and a circular base plate with spherically curved concave upper surface. The base plate shall be recessed into the bottom keeper plate. Polytetrafluoroethylene (PTFE) shall be recessed and bonded to the upper concave surface of the base plate.

The middle unit shall be a bearing plate with a spherically curved convex lower surface and a flat upper surface. The convex lower surface shall be stainless steel. Polytetrafluoroethylene (PTFE) sheets shall be recessed and bonded to the upper surface of the middle unit.

The upper unit shall be a sole plate with a cylindrical cavity machined out of it. Walls of the cavity shall form the external restrainer. The lower surface of the sole plate inside the cavity shall have stainless steel sheet welded to it.

#### Guided Spherical Bearings With External Restrainer

Each bearing shall consist of an upper, a middle, and a lower unit. Lower and middle units shall be as specified for the fixed spherical bearings with external restrainer.

The upper unit shall be a sole plate to which guide bars, if shown in the Plans, shall be recessed and bolted. The lower surface of the steel plate between the guide bars shall have stainless steel welded to it.

Restraining effect shall be accomplished by installing a restraining plate in between the lower unit and the guide bars. Restraining plate shall be a flat plate with a circular hole in the middle. Different surfaces of the restraining plate shall be compatible with the mating surfaces. Polytetrafluoroethylene (PTFE) sheets shall be recessed and bonded to the upper, lower, and other sides (mating with the guide bars) of the restraining plate. The stainless steel sheets shall be welded to the sides of the guide bars mating with the restraining plate.

#### Fixed Spherical Bearings Without External Restrainer

Each bearing shall consist of an upper and lower unit. The lower unit shall be a masonry plate and a circular base plate with spherically curved convex upper surface. The base plate shall be recessed into and welded to the masonry plate. The convex upper surface shall be stainless steel.

The upper unit shall be a sole plate and a circular bearing plate with spherically curved, concave lower surface. The bearing plate shall be recessed and welded to the sole plate. Polytetrafluoroethylene (PTFE) sheet shall be recessed and bonded to the concave surface.

**Guided Spherical Bearings Without External Restrainer**

Each bearing shall consist of an upper, a middle, and a lower unit. The lower unit shall be a masonry plate, a bottom keeper plate, and a circular base plate with a spherically curved convex upper surface. The base plate shall be recessed into the bottom keeper plate. The convex upper surface of the base plate shall be stainless steel.

The middle unit shall be a bearing plate with a spherically curved concave lower surface and a flat upper surface. Polytetrafluoroethylene (PTFE) sheets shall be recessed and bonded to the upper and lower surfaces of the middle unit.

The upper unit shall be a sole plate and a top keeper plate to which guide bars, if shown in the Plans, shall be recessed and bolted. The lower surface of the top keeper plate between the guide bars shall have stainless steel sheet welded to it. The interspace between the guide bars and the middle unit bearing plate shall be provided with a stainless steel sheet against PTFE. The stainless steel sheet shall be welded to the guide bars and the PTFE sheet shall be recessed and mechanically bonded to the middle unit bearing plate.

**Multi-Directional Spherical Bearings Without External Restrainer**

Each bearing shall consist of an upper, a middle, and a lower unit. The lower unit shall be a masonry plate, a bottom keeper plate, and a circular base plate with a spherically curved convex upper surface. The base plate shall be recessed into the bottom keeper plate. The convex upper surface of the base plate shall be stainless steel.

The middle unit shall be a bearing plate with a spherically curved concave lower surface and a flat upper surface. Polytetrafluoroethylene (PTFE) sheets shall be recessed and bonded to the upper and lower surfaces of the middle unit.

The upper unit shall be a sole plate and a top keeper plate. The lower surface of the sole plate shall have stainless steel sheet welded to it.

**Design Requirements**

The Contractor shall design the bearing assemblies based on the current AASHTO LRFD Bridge Design Specifications, including current interims, and also based on the following:

1. The bearing assembly design requirements for loads, movements, and rotations shall be as shown in the Plans.

2. The bearing assembly shall have an external restrainer when the horizontal design force of a design load combination exceeds 25

percent of the simultaneous vertical design force. The external restrainer shall be capable of withstanding the full horizontal design force as shown in the Plans.

3. The bearing assembly shall be removable and replacable by raising the bridge superstructure six millimeters maximum. The bearing shall be held in place by recessing the upper and lower keeper plates and by providing recessed bolted keeper bars on the side of bearing removal.

4. The area of the PTFE surface shall be designed so that the average bearing pressure does not exceed the maximum contact pressure specified in Table 14.7.2.4-1 of the AASHTO LRFD Bridge Design Specifications. The contact stress shall be determined at the strength limit state as specified in Section 14.7.2.4 of the AASHTO LRFD Bridge Design Specifications.

5. The mechanical interlock of the solid or woven PTFE sheets to the steel substrates shall be sufficient to develop a horizontal force equal to 10 percent of the maximum unfactored vertical load for bearings with an external restrainer, and 25 percent of the maximum unfactored vertical load for bearings without an external restrainer.

6. The minimum coefficient of friction on PTFE surfaces used for design shall be those corresponding to 20C in Table 14.7.2.5-1 of the AASHTO LRFD Bridge Design Specifications.

7. The anchorage of the sole plates, masonry plates, and guide bars to the supporting structural element shall be designed for the maximum unfactored horizontal design force per bearing shown in the Plans, or 10 percent of the maximum unfactored vertical design force per bearing, whichever is greater.

8. The sole and masonry plates shall have leveling capabilities.

9. The guide bars shall maintain all guided components within the guides at all points of translation and rotation of the bearing.

**Submittals**

**Design Calculations**

The Contractor shall submit design calculations for all the bearing components, including the base plates, bearing plates, sole plates, masonry plates, keeper plates and bars, and anchor bolts to the Engineer for approval in accordance with Section 6-02.3(16). The design calculations shall accompany the shop plans.

The calculations shall provide, but not be limited to the following information:

1. Bending stresses in the plates due to bearing pressure at maximum design load and eccentricity.

2. Concrete bearing pressure under the plates at maximum bearing pressure and eccentricity.

3. Bearing clearances at maximum load and rotation. The calculated clearances shall include the effects of anticipated initial set and modified center of rotation.

4. Design of all connections and mating surfaces.

5. Compressive stress on all sliding surfaces at maximum and minimum design loads, including rotation.

The Contractor shall not begin bearing fabrication until receiving the Engineer's written approval of the calculations.

**Bearing Manufacturer Requirements**

The spherical bearing manufacturer shall have a minimum of three years experience in fabrication of spherical bearings, and shall meet additional testing requirements as specified in this Special Provision.

The Contractor shall submit the name of the spherical bearing manufacturer with a certification of spherical bearing manufacturing experience to the Engineer for approval. The certification of experience shall include a list of at least three spherical bearing installations performed by the bearing manufacturer on previous projects. The list shall include the following information for each installation:

1. Project Name and Location (Bridge name and highway number).

2. Date of installation.

3. Governmental Agency/Owner.

4. Name, address, and phone number of the Governmental Agency's/Owner's representative.

The Contractor shall not begin preparation of the design calculations and shop plans until receiving the Engineer's written approval of the bearing manufacturer's certification of experience.

**Shop Drawings**

The Contractor shall submit shop drawings to the Engineer for approval in accordance with Section 6-03.3(7). These drawings shall include but not be limited to the following information:

1. Bearing schedule identifying location and bearing type as described in subsection **Bearing Types** of this Special Provision.

2. Minimum and maximum horizontal and vertical service loads.

3. Magnitude and direction of movements at all bearing support points.

4. Minimum and maximum rotation capacity.

5. Construction rotation requirements.

6. Plan and elevation of the assembled bearing and each of the components showing dimensions and tolerances.

7. Complete details of all components and sections showing all materials incorporated into the bearing.

8. All AASHTO, ASTM, and other material designations.

9. All surface finishes.

10. Bearing manufacturer's recommendations and procedures for bearing assembly shipment, storage, and installation.

The Contractor shall not begin fabricating the spherical bearings until receiving the Engineer's approval of the shop drawings.

**Shop Inspection**

The manufacturer shall provide for inspection, as specified in the **Bearing Inspection and Acceptance** subsection of this Special Provision. Inspection during the fabrication process shall ensure that the materials and workmanship meet the requirements of the contract.

Quality Assurance Inspection and Final Shop Inspection shall be performed by an independent inspection entity approved by the Engineer. The Contractor shall submit the name, address, phone number and contact person of the inspection entity performing the required certified shop inspection of the bearings to the Engineer for approval. The Contractor shall not begin bearing fabrication until receiving the Engineer's written approval of the inspection entity for certified shop inspection.

**Bearing Testing Procedure**

The Contractor shall submit the name, address, phone number, and contact person of the testing entity performing the required bearing testing specified in **Bearing Testing** subsection of this Special Provision to the Engineer for approval.

The testing entity shall be one of the following:

1. An independent testing agency.

2. The spherical bearing manufacturer, with independent verification by the inspection entity performing the certified shop inspection of the bearings.

The Contractor shall not begin bearing fabrication until receiving the Engineer's written approval of the testing entity.

**Bearing Assembly Inspection Reports and Certificates**

The Contractor shall submit the daily inspection reports of the independent inspection entity performing the required certified shop inspection to the Engineer for approval. The daily inspection reports shall report on the shop fabrication and testing activities relating to the bearing assemblies, and their conformance to the specification requirements.

The Contractor shall submit written documentation from the bearing manufacturer certifying that the bearing assemblies have been manufactured in full compliance with the specification requirements.

The Contractor shall not ship the bearing assemblies from the fabricator's facility until receiving the Engineer's approval of the certified shop inspection daily inspection reports and the bearing manufacturer's certificate of compliance.

**Flatness and Manufacturing Tolerances**

Flatness of bearing surfaces shall be determined by the following method:

1. A precision straightedge, longer than the nominal dimension to be measured shall be placed in contact with the surface to be measured as parallel to it as possible.

2. A feeler gauge having an accuracy of $\pm$ 0.001 inches equal to the tolerance allowed shall be selected and inserted under the straightedge.

3. If the feeler gauge does not pass under the straightedge, the surfaces shall be acceptable for flatness.

4. In determining the flatness, the straightedge may be located in any position on the surface being measured.

Flatness tolerances shall be defined as follows:

1. Class A tolerance = 0.001 x nominal dimension

2. Class B tolerance = 0.002 x nominal dimension

3. Class C tolerance = 0.005 x nominal dimension

(Nominal dimension shall be taken as the actual dimension of the plate or sheet under the straightedge, in inches.)

Manufacturing tolerances for the bearings are as follows:

Sole, Bearing, Base, and Masonry Plate, and Keeper Plate and Bar

| | |
|---|---|
| Plan dimensions | |
| Greater than 760 mm: | -0.00, +4.76 millimeters |
| 760 mm or less: | -0.00, +3.18 millimeters |
| Thickness: | |
| Unmachined: | -0.794, + 3.18 millimeters |
| Both Faces Machined: | ± 0.254 millimeters |
| One Face Machined: | ± 0.0508 millimeters |
| Flatness: | Class A tolerance, side in contact with steel or PTFE |
| | Class C tolerance, side in contact with grout or concrete |

The maximum gap between the external restrainer and the circular base plate, and the walls of a recess and a recessed plate shall be 1.02 millimeters.

Spherically Curved Surfaces

| | |
|---|---|
| Radii: | ± 1 percent, surfaces shall be parallel to each other. |
| Profile of Spherical Surfaces: | ± 0.00000031D h or ± 0.20 millimeters, whichever is greater, where D = length of chord (in millimeters) between the ends of the PTFE surface in the direction of rotation, and h = projection of the PTFE (in millimeters) above the top of the confining recess. |

Guide Bar

| | |
|---|---|
| Length: | ± 3.18 millimeters |
| Section dimensions: | ± 1.59 millimeters |
| Flatness: | Class A tolerance, side in contact with steel |
| Bar to bar tolerance: | ± 0.794 millimeters |

Bars shall be not more than 0.794 millimeters out of parallel

PTFE Sheet

| | |
|---|---|
| Plan dimensions: | Total nominal design area –0, +5 percent |
| Thickness: | -0.00, +0.397 millimeters inch |
| Flatness: | Class A tolerance |
| PTFE Recess: | Length and width –0.00, +1.02 millimeters |

Stainless Steel Sheet

| | |
|---|---|
| Flatness: | Class A tolerance |

Overall Height

| | |
|---|---|
| Total thickness: | -0.159, +4.76 millimeters |

The edges of all components shall be broken by grinding so that there are no sharp edges.

**Special Fabrication Requirements**

When the following components are shown in the Plans as part of the spherical bearing assembly, the following special fabrication requirements shall apply:

**Sole Plate and Masonry Plate**

The sole plate and masonry plate shall be 20 millimeters minimum thickness, unless otherwise shown in the Plans.

**PTFE Sheet**

The thickness of solid PTFE sheet shall be a minimum of 3.18 millimeters and a maximum of 4.76 millimeters. Solid PTFE sheet shall be recessed for a depth equal to one-half of its thickness into the material it is bonded to.

The thickness of woven PTFE fabric, if used, shall be a minimum of 1.59 millimeters and a maximum of 3.18 millimeters.

Dimpled PTFE, if shown in the Plans, shall be unfilled and shall have a maximum thickness of 4.76 millimeters. Dimples shall be placed on a 12.7 millimeter grid and have a depth of 1.59 millimeters.

The PTFE sheet shall be recessed and chemically bonded to the supporting steel plate or bar. The woven PTFE sheet shall be mechanically bonded to the supporting steel plate or bar by using an interlocking grid. Bonding shall be performed under controlled conditions and in accordance with the written instructions of the PTFE manufacturer.

Following the bonding operation, the PTFE surface shall be smooth and free from bubbles. Filled PTFE shall be polished after the bonding operation is complete, in accordance with AASHTO LRFD Bridge Construction Specification Section 18.8.3.2.2.

**Stainless Steel Sheet**

The stainless steel sliding surface shall completely cover the PTFE surface in all operating positions plus 25.4 additional millimeters in all directions.

The stainless steel shall be 14 gage thick for the main sliding surfaces and 10 gage thick for the guide bars.

The curved surfaces that receive stainless steel shall be weld overlaid to produce a surface chemistry equivalent to ASTM A 240 Type 304L stainless steel.

Stainless steel welded overlay on the curved surface shall be a minimum of 2.34 millimeters thick after welding, grinding, and polishing.

The stainless steel sheet shall be seal welded all around to the supporting steel plate or bar by the gas tungsten arc welding (GTAW) process in accordance with current AWS specifications. The stainless steel sheet shall be clamped down to have full contact with the supporting steel plate or bar during welding. The welds shall not protrude beyond the sliding surface of the stainless steel sheet.

**Guide Bar**

Each guide bar shall be fabricated from a single steel plate. The guide bars shall be connected to the spherical bearing assembly by recessing and bolting. The stainless steel sheet shall be welded to the guide bar before attaching the guide bar to the spherical bearing assembly. The space between the guide bar and the guided component shall be $4.76 \pm 1.59$ millimeters.

**Corrosion Protection**

Steel surfaces, except as otherwise specified, shall be painted in accordance with Section 6-07.3(1), and Section 6-03.3(30) as supplemented in these Special Provisions. The weld surfaces fastening stainless steel to structural steel shall be painted as specified for structural steel. Stainless steel shall not be painted. The second and third coats of paint shall be applied after the spherical bearing assembly has been erected in its final position with the anchor bolt nuts installed.

The anchor bolts, and associated nuts and washers and pipe assembly, shall not be painted. The upper portion of the anchor bolts, and associated nuts and washers, to 150 millimeters minimum below the concrete surface, shall be galvanized after fabrication in accordance with AASHTO M 232.

**Bearing Testing**

The Contractor shall provide for testing of the bearings. The testing shall be performed by the testing entity submitted by the Contractor and approved by the Engineer as specified in the **Bearing Testing Procedure** subsection of this Special Provision.

All testing specified by this Special Provision performed by the bearing manufacturer shall be witnessed by the inspection entity performing the certified shop inspection of the bearings.

When fabrication of the bearings is complete, a Wear and Damage Characteristics test shall be performed either on bearing assemblies randomly selected from the production bearings, or on an equal number of prototype bearings with a minimum design capacity of 4.448 kilonewtons. One bearing per lot shall be tested where one lot is defined as the smaller of the following:

1. 25 spherical bearing assemblies.

2. The total quantity of spherical bearing assemblies specified in the contract.

The Wear and Damage Characteristics test shall be performed on the selected test bearing assemblies as follows:

1. The bearing shall be subjected to 5,000 cycles of rotation (2.0 degrees each direction from level, 4.0 degrees total rotation) under the specified vertical dead load plus live load.

2. After completing the load cycles, the bearing shall be disassembled and inspected for wear and damage. A 0.397 millimeter reduction in PTFE thickness, or damage to the bearing, shall be cause for rejection of the bearing assembly.

3. The test bearing shall show no signs of defects and failure while under load, and after disassembly and inspection.

Failure of the test bearing will result in rejection of all bearings.

The testing requirements specified above may be waived for bearing manufacturers with at least three years of spherical bearing fabrication experience provided:

1. The bearing manufacturer, through the Contractor, shall submit certified test results from a previous installation of spherical bearings of similar design and load capacity to the Engineer for approval. This submittal shall accompany the design calculation and shop plan submittal.

2. The tests performed on the previously installed bearings satisfy the requirements specified above.

3. All test requirements not performed on and not satisfied by the previously installed bearings shall be performed on and satisfied by a test bearing in this contract through a Wear and Damage Characteristics test as specified above.

The test bearing may be used as a production bearing provided:

1. The test results meet with the approval of the Engineer.

2. The test bearing was selected from the production bearings.

3. All PTFE in the test bearing assembly shall be replaced with new PTFE.

**Bearing Inspection and Acceptance**

Three levels of inspection shall be satisfied before the bearings are accepted. These are: Quality Control Inspection, Quality Assurance Inspection, and Final Shop Inspection. The manufacturer shall provide for both Quality Control and Quality Assurance Inspection. The manufacturer shall provide access for the Final Shop Inspection. The three levels of inspection are described below:

1 Quality Control Inspection
During the fabrication process of all major components, the manufacturer shall provide full time Quality Control Inspection to ensure that the materials and workmanship meet or exceed the minimum requirements of the contract. Quality Control Inspection shall be the responsibility of the manufacturer's quality control group, which shall be independent of the fabrication group.

2. Quality Assurance Inspection
Quality Assurance Inspection shall be performed by the independent inspection entity performing the certified shop inspection, as submitted by the Contractor and approved by the Engineer. The independent inspection entity, the proposed Quality Assurance Inspection Program, and the forms to be used for the Quality Assurance Program shall be submitted to the Engineer for approval prior to the start of fabrication. Quality Assurance Inspection is not required to be full time inspection, but shall be done at all phases of the manufacturing process. The frequency of inspection shall be included in the Quality Assurance Inspection Program.

3. Final Shop Inspection
Prior to shipping the bearings to the job site, a representative number of bearings shall be inspected by the independent inspection entity at the manufacturer's facility. The manufacturer shall provide a clean, dry, and enclosed area for the bearing inspection. The manufacturer shall disassemble and reassemble the bearings for inspection by the independent inspection entity. The independent inspection entity shall certify that the bearings have been inspected, and that the bearings have been manufactured in full compliance with the contract requirements.

The bearings shall satisfy each of the three levels of inspection described above before they will be accepted. Bearings that fail any one of the three levels of inspection shall be replaced or repaired as approved by the Engineer at no additional expense to the Contracting Agency. All proposed corrective procedures shall be submitted by the Contractor to the Engineer for approval before beginning corrective work.

**Bearing Component Assembly, Shipping, and Storage**

Each bearing, except bearing components welded to the bottom flange of steel girders, shall be fully assembled at the manufacturing plant and delivered to the construction site as a complete unit, ready for installation. The units shall be held together with removable restraints so that the sliding surfaces are not damaged.

All bearing assemblies shall be marked with the following information prior to shipping:

1. Location of the bearing, including the pier and the specific location along the pier.

2. Direction arrow pointing in the ahead on station direction.

The above information shall be marked on the top plate of the upper unit of the bearing assembly. The marks shall be permanent and shall be visible after bearing installation.

The bearing assemblies shall have centerlines marked on both upper and lower units for checking alignment in the field.

The bearing assemblies shall be shipped in light-proof, moisture-proof and dust-proof containers.

**Bearing Assembly Field Inspection**

Field inspection of a representative number of bearings assemblies will be performed by the Engineer. The Contractor shall provide a clean, dry and enclosed area at the site, spacious enough for the field inspection activities. The Contractor shall disassemble and reassemble the bearings for inspection by the Engineer. The disassembly and reassembly of the bearings shall be in accordance with the bearing manufacturer's written procedure and in the presence of the Engineer.

Bearings that fail the inspection shall be replaced or repaired by the Contractor, as approved by the Engineer, at no additional expense to the Contracting Agency. All proposed corrective procedures shall be submitted by the Contractor to the Engineer for approval before beginning corrective work.

**Bearing Assembly Installation**

The Contractor shall install the spherical bearing assembly in accordance with the installation procedure included with the shop drawing submittal as approved by the Engineer. After installation, the orientation of the spherically curved units shall be $\pm$ 1/2 degree from level.

PTFE sheet shall not be greased, except as otherwise noted. A thin uniform film of silicone grease shall be applied to the entire dimpled PTFE sheet before installation (all dimples shall be filled with grease).

For spherical bearing assemblies with PTFE and stainless steel components, the Contractor shall take special care at all times to ensure protection of the PTFE and stainless steel surfaces from coming in contact with concrete and any other foreign matter.